MICOM-BASED NOWCAST/FORECAST SYSTEM FOR COASTAL/OPEN OCEAN REGIONS

Eric P. Chassignet and Rainer Bleck
Meteorology & Physical Oceanography
University of Miami/RSMAS
4600 Rickenbacker Causeway, Miami, FL, 33149-1098
Phone: (305)361-4041 Fax: (305)361-4696 Email: echassignet@rsmas.miami.edu

Award #: N00014-99-1-0048

http://www.rsmas.miami.edu/groups/micom.html

LONG-TERM GOALS

To develop a nowcast/forecast system for coastal/open ocean regions with the hybrid version (HYbrid Coordinate Oceam Model   HYCOM) of the Miami Isopycnic Coordinate Ocean Model (MICOM) (Bleck and Chassignet, 1994).

OBJECTIVES

a) To evaluate the model's performance in reproducing the oceanic circulation, with a special focus on the coastal regions;

b) To evaluate the model's forecast skills and usefulness in providing boundary conditions for ultra fine-mesh coastal models.

APPROACH

A series of numerical models of increasing complexity and resolution is used to (a) evaluate the model's forecast skills and (b) develop an understanding of the interaction between the ocean interior and the coastal regions.

WORK COMPLETED

a) 20-year integration of the high resolution ($1/12^o$, mesh size on the order of 6 km) North Atlantic DAMEE-NAB (Data Assimilation and Model Evaluation Experiment - North Atlantic Basin) experiment (Chassignet *et al.*, 1998; Garraffo *et al.*, 1999; Paiva *et al.*, 1999; http://www.rsmas.miami.edu/groups/micom.html)

b) Inclusion of the K-Profile Parameterization (KPP) mixing model in HYCOM

c) Open boundary conditions for HYCOM

d) Data assimilation capabilities for MICOM (Chin *et al.*, 1999)

e) Several process studies on boundary current separation and gyre dynamics (Özgökmen *et al.*, 1999; Stern and Chassignet, 1999; Pratt *et al.*, 1999)

RESULTS

In the fine mesh North Atlantic simulation, baroclinic instabilities are well resolved by the grid spacing since the latter is less than the first Rossby radius of deformation

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **30 SEP 1999**	2. REPORT TYPE	3. DATES COVERED **00-00-1999 to 00-00-1999**
4. TITLE AND SUBTITLE **MICOM-Based Mowcast/Forecast for Coastal/Open Ocean Regions**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **University of Miami,Rosenstiel School of Marine and Atmospheric Science,4600 Rickenbacker Causeway,Miami,FL,33149**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a REPORT **unclassified**	b ABSTRACT **unclassified**	c THIS PAGE **unclassified**	**Same as Report (SAR)**	**6**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

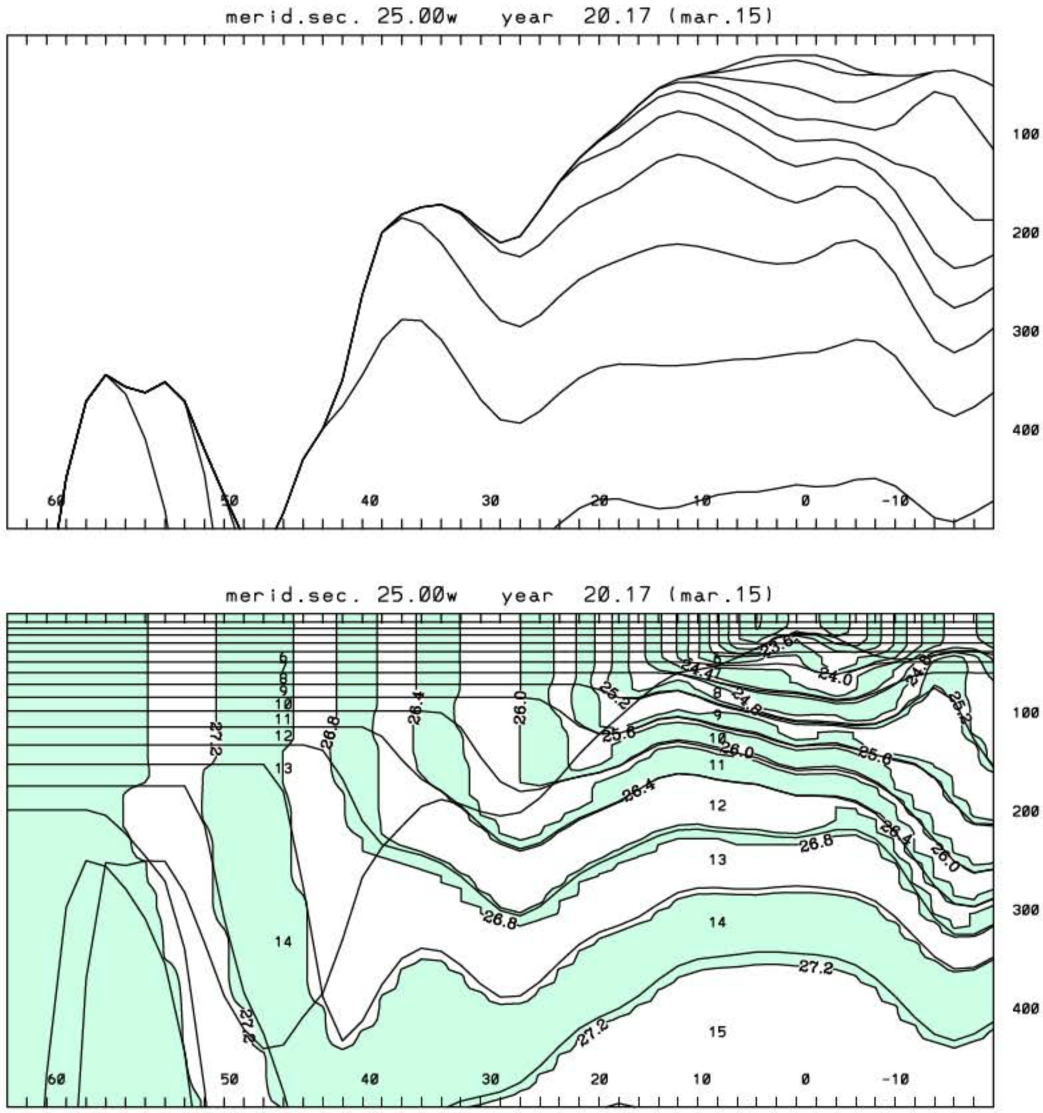


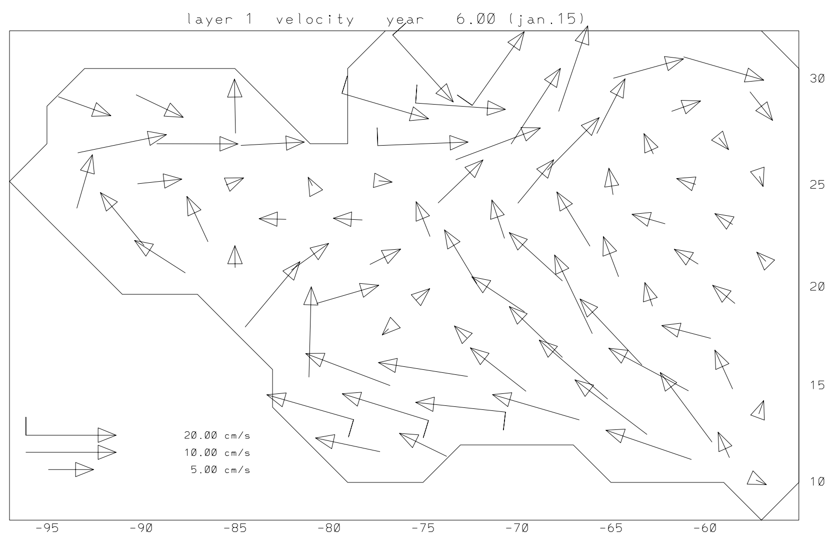
Figure 1: Vertical section at 25^{o}W in January of year 21. Upper panel: MICOM. Lower panel: HYCOM. Thin solid lines: layer interfaces. Shaded fields; density. Depth range: 500 m.

throughout the domain. The turbulent behavior of the simulation has been assessed by Paiva *et al.* (1999). Sea surface height variability spectra in the North Atlantic subtropical gyre were computed from the model results and compared to observations and previous models, within the framework of the geostrophic turbulence theory. A model/data comparison was also performed between numerically simulated drifters and data from *in-situ* surface drifters (Garraffo *et al.*, 1999). The comparison makes use of pseudo-Eulerian statistics such as mean velocity and eddy kinetic energy, and Lagrangian statistics such as integral time scales. The space and time distribution of the two data sets differ in the sense that the *in-situ* drifters were released inhomogeneously in space and time while the simulated drifters were homogeneously seeded at the same time over a regular 1^o grid. Despite this difference, the total data distributions computed over the complete data sets exhibit similarities that are mostly related to the large scale pattern of Ekman divergence/convergence. As in Paiva *et al.* (1999), the comparison indicates that the numerical model represents correctly the eddy kinetic energy in the main current systems, while it underestimates it in the ocean interior.

The hybrid coordinate, in the context of our ONR sponsored work, is one that is isopycnal in the open, stratified ocean, but smoothly reverts to a terrain-following coordinate in shallow coastal regions, and to z-level coordinates in the mixed layer and/or unstratified seas. The capability of assigning additional coordinate surfaces to the oceanic mixed layer gives us the option of replacing the slab-type Kraus-Turner mixed layer of MICOM by a more sophisticated closure scheme in HYCOM, such as K-Profile Parameterization (KPP) (Large *et al.*, 1997) (Figure 1). The latter was implemented and HYCOM is presently being tested on a coarse resolution North Atlantic domain. A scalable version of the code will be available to the community by the end of 1999.

Given that a strong focus of the research performed at the University of Miami is real-time forecasting of both Eulerian fields, such as temperature and velocity, and Lagrangian trajectories, data assimilation methods are being developed and evaluated (Chin *et al.*, 1999). The five primary components of this effort are (i) MICOM/HYCOM, (ii) satellite-derived sea surface temperature and height fields and data from Lagrangian drifters, (iii) an Extended Kalman Filter (EKF) with a second-order Gauss-Markov Random Field (GMRF) model for spatial covariances, (iv) a random flight turbulence model for Lagrangian trajectory prediction, and (v) parameter estimation and assimilation techniques.

In addition to data assimilation capabilities, an effective nowcast/forecast regional system needs high quality lateral boundary conditions. Because of the sparseness in time and space of observations, one must rely either on climatology or on larger scale numerical simulations. Large-scale numerical simulations are numerically demanding at the needed resolution (less than 10 km grid spacing) and one needs to determine if coarser mesh runs can provide useful boundary conditions. This is presently being done by using the fine mesh North Atlantic basin simulation as the "reference" experiment in a series of nested (coarse/fine) runs. The test region is the Carribean Sea (Figure 2) and the effectiveness of the existing boundary treatment (and possi-



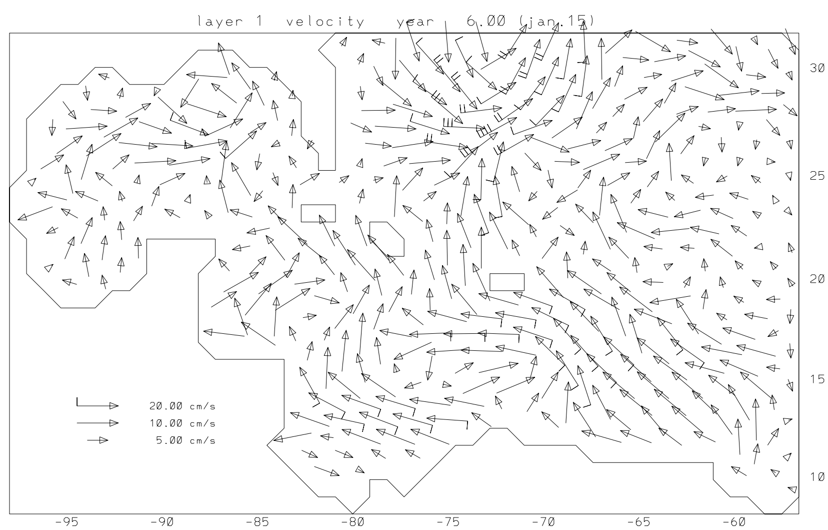


Figure 2: HYCOM surface velocities in the Carribean Seas in the 2^o mesh North Atlantic control run (upper panel) and with finer resolution (1^o) using boundary conditions from the control run.

bly others) is tested by using a) degraded high resolution fields (various space and time filters) and b) fields from coarser resolution simulations (with and without data assimilation).

IMPACT/APPLICATIONS

This research has potential for providing the large scale information needed as boundary conditions for forecasting with regional coastal models.

TRANSITIONS

The data from the $1/12^o$ run are presently being analyzed in collaboration with observationalist W. Johns.

RELATED PROJECTS

Collaborations are active with scientists at NRL (H. Hurlburt and A. Wallcraft) as well as with ONR sponsored PIs (M. Chin, A. Griffa, W. Johns, and A. Mariano).

REFERENCES

Bleck, R., and E.P. Chassignet, 1994: Simulating the oceanic circulation with isopycnic coordinate models. *The Oceans: Physiochemical Dynamics and Resources.* The Pennsylvania Academy of Science, 17-39.

Large, W.G., G. Danabasoglu, S.C. Doney, and J.C. McWilliams, 1997: Sensitivity to surface forcing and boundary layer mixing in a global ocean model: Annual-mean climatology. *J. Phys. Oceanogr.*, **27**, 2418-2447.

PUBLICATIONS (1998-1999)

Chassignet, E.P., and J. Verron (Eds.), 1998: *Ocean Modeling and Parameterization.* Kluwer Academic Publishers, 451 pp.

Chassignet, E.P., Z.D. Garraffo, and A.M. Paiva, 1998: Fine-mesh ($1/12^o$ degree) numerical simulation of the North Atlantic: The meridional overturning circulation and associated water mass transformations, *EOS*, 1998 Ocean Sciences Meeting.

Chin, T.M., A.J. Mariano, and E.P. Chassignet, 1999: Spatial regression with Markov random fields for Kalman filter approximation in least-squares solution of oceanic data assimilation problems. *J. Geophys. Res.*, **104**, 7991-8014.

Paiva, A.M., J.T. Hargrove, E.P. Chassignet, and R. Bleck, 1999: Turbulent behavior of a fine mesh (1/12 degree) numerical simulation of the North Atlantic. *J. Mar. Sys.*, **21**, 307-320.

Sun S., R. Bleck, C.G. Rooth, J. Dukowicz, E.P. Chassignet, and P. Killworth, 1999: Inclusion of thermobaricity in isopycnic-coordinate ocean models. *J. Phys. Oceanogr.*, **29**, 2719-2729.

Smith, L.T., E.P. Chassignet. and R. Bleck, 1999: The impact of lateral boundary conditions and horizontal resolution on North Atlantic water mass transformations and pathways in an isopycnic coordinate ocean model. *J. Phys. Oceanogr.*, in press.

Paiva, A.M., E.P. Chassignet, and A.J. Mariano, 1999: Numerical simulations of the North Atlantic subtropical gyre: Sensitivity to boundary conditions and horizontal resolution. *Deep-Sea Res.*, accepted.

Pratt, L.J., K.R. Helfrich, and E.P. Chassignet, 1999: Long's problem in a rotating channel. *J. Fluid Mech.*, submitted.

Stern, M.E., and E.P. Chassignet, 1999: Mechanism of eddy separation from coastal currents. *J. Mar. Res.*, submitted.

Özgökmen, T.M., E.P. Chassignet, and C.G.H. Rooth, 1999: On the connection between the Mediterranean outflow and the Azores Current. *J. Phys. Oceanogr.*, submitted.

Garraffo, Z.D., A.J. Mariano, A.Griffa, C. Veneziani, and E.P. Chassignet, 1999: Lagrangian data in a high resolution numerical simulation of the North Atlantic. I: Comparison with *in-situ* drifter data. *J. Mar. Sys.*, submitted.